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Research on the Circular Economy in West China

YANG Qing[a*], CHEN Mingyue[a], GAO Qiongqiong[a]

[a]*Management School of Northwestern Polytechnical University, Xi`an, 710072, China*

Abstract:

This paper analyses the development of circular economy in the western part of China, a hierarchical structure model and an evaluation index system to appraise the development of circular economy are established, then the development of circular economy appraisal of several province in the western part of China was conducted by using the method of principal component analysis and analyses some existence questions. The research conclusion is that: the circular economy situation of Shaanxi, Gansu, Qinghaiprovince is relatively bad, the Xinjiang is the worst. They take an extensive development path and have paid great resources and environmental cost. They need to strengthen the construction of circular economy system, accelerate economic development model transformation.

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Key words: Circular economy, sustainable development, principal component analysis;

1. Introduction

Here follows further instructions for authors. Circulation economy is one kind of ecology economy with resource conservation and environment optimization. The developed countries take developing circular economy and establishing resource-conserving society as important approaches and ways to implement the sustainable development strategy [1]. In the 1990s, with the sustainable development strategy reached a consensus in the world, the model of circular economy really began to form in international world [2]. Since China's reform and opening-up, economic and social development has made great achievements, but the extensive economic growth mode with high input, high consumption and high emissions have no fundamental change, though it has brought the rapid economic growth, but also brought serious environmental pollution and tremendous waste of resources.

* Corresponding author. Tel.: + 86 29 13709263879;.
E-mail address: ytsing212@nwpu.edu.cn.

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Especially in the western regions of China, where are taken as China's "ecological barrier" and "resources treasure house", the contradictions between economic development and environmental protection are very prominent. Developing circular economy becomes an inevitable choice. This paper presents a research on the development status of the western region and the promotion mechanism of circular economy, promoting the healthy development of social economy in western China.

2. Model

Reference to the "evaluation index system of circular economy (macro)" [3] which issued by China's National Development and Reform Commission, combined with the status of west China, select four factors: the resource consumption, resource recycling, environmental protection and economic development as the main classified indexes to evaluate the circular economy development situation of China's western provinces, establish the evaluation index system of circular economy in west China as is shown in table 1.

Table 1 Circular economy assessment index system of China's western region

Classified indexes	Individual indicators	Unit	Orientation
Index of energy consumption	X_1: Energy consumption/GDP	tce/10^4yuan	−
	X_2: Energy consumption / industrial added value	tce/10^4yuan	−
	X_3: Electricity consumption/GDP	kw·h/10^4yuan	−
	X_4: Water consumption/industrial added value	tn/10^4yuan	−
	X_5: Intensity of fertilizer application	tn / ha	−
	X_6: Level of pesticide application	tn / ha	−
Index of resource recycling and reuse	X_7: Ratio of industrial solid wastes utilized	%	+
	X_8: Output value of products Made from utilization/ gross industrial output value	%	+
	X_9: Total marsh gas production	10^4 m^3	+
Index of resource and environment protection	X_{10}: Ratio of industrial waste water meeting discharge standards	%	+
	X_{11}: Removed rate of industry sulphur dioxide	%	+
	X_{12}: Removed rate of industrial soot	%	+
	X_{13}: Treatment rate of consumption wastes	%	+
	X_{14}: Investment in the treatment of industrial pollution/GDP	%	+
	X_{15}: Per capita public greenbelt area	m^2/ person	+
	X_{16}: Forest coverage rate	%	+
Index of economy and social development	X_{17}: Per capita GDP	yuan/ person	+
	X_{18}: Per capita net income of rural households	yuan	+
	X_{19}: Per capita disposable income of urban households	yuan	+
	X_{20}: The proportion of tertiary industry	%	+
	X_{21}: The proportion of high-tech industrial output value	%	+

Explanations for indicators: Intensity of fertilizer application= Chemical fertilizer consumption /cultivated land,Level of pesticide application= Pesticides consumption/cultivated land

3. Research methods

In this paper, factor analysis was chose as the main method, then using SPSS15.0 software analysis and calculation as the following steps [4]:

(1)Establish the index system of the original matrix Z.

(2)In order to eliminate the dimensional effects, the original data was standardized and a standardization matrix X was got. The standardized formula is $x'_{ij}=(x_{ij}-\bar{x}_j)/d_j$, $i=1, 2\ldots n$; n is the number of samples, $j=1, 2\ldots m$; m is the sample of the original number of variables.

(3)Get the correlation matrix R through the calculation of Z or X, and then make sure that several of the original variables to be analyzed are suitable for the factor analysis, if most of the correlation coefficients are greater than 0.3 in the correlation coefficient statistical test of the matrix and past the statistical test, the variables are suitable for factor analysis.

(4)Calculate the characteristic value of matrix R and determine the corresponding eigenvectors and contribution rate. Starting from the correlation matrix R of sample for characteristic analysis: from $RU=\lambda U$ can get $|R-\lambda I|=0$, all the characteristic roots can be calculated in accordance with the size of the order : $\lambda_1\geq\lambda_2\geq\ldots\ldots\geq\lambda_p\geq\lambda_0$, the standardization of corresponding eigenvectors Ui ($i=1, 2\ldots\ldots p$) and the contribution rate (in general value it is over 85%) can also be got. In the end, determine the factors number of p.

(5)Give a reasonable explanation and name for each factor.

(6)Calculate the initial factor of the loading matrix $A=(a_{ij})_{p\times m}=(\mu_{ij})_{p\times m}$.

(7)Establish a factor model $X_i=\sum_{i=1}^{m} a_{ij}? F_j \quad e_i$, $i=1, 2\ldots p$. $F_1, F_2, \ldots F_m$, e_i are Special factors.

(8)Give an orthogonal rotation transformation to the initial factor loading matrix, getting a more ideal new factor loading matrix $A'=(a'_{ij})_{p\times m}$.

(9) Calculate the scores of the principal factors. Then, take the factor contribution rate as weights and calculate the composite score of each sample. In the end, compare and evaluate the level of the indexes according to the composite scores of the sample.

4. Data processing and analysis

According to the circular economy evaluation index system listed in table1, collect the index data of the 11 provinces and municipalities in the west of China from the China statistical yearbook of 2009[5], and use SPSS software for data processing and analysis[6].

Table 2 Original data of 12 provinces and municipalities in western China。

ex	Western Region of China										
	Neimenggu	Guangxi	Chongqing	Sichuan	Guizhou	Yunnan	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang
1	2.159	1.106	1.267	1.381	2.875	1.562	1.281	2.013	2.935	3.686	1.963
2	4.19	2.335	2.106	2.477	4.323	2.847	2.009	4.05	3.243	7.13	2.999
3	1887.32	1254.15	1090.19	1156.37	2452.21	1654.94	1256.02	2539	4061.64	5084.09	1331.24
4	53.967	196.773	225.889	117.209	272.019	107.441	39.163	107.231	178.390	67.328	54.727
5	0.225	0.391	0.274	0.257	0.180	0.277	0.398	0.210	0.158	0.288	0.332
6	0.003	0.011	0.007	0.006	0.003	0.007	0.003	0.009	0.004	0.002	0.004
7	49.350	62.415	80.095	61.665	40.024	47.921	40.288	35.136	31.114	62.730	47.949
8	0.282	0.638	0.468	0.412	0.592	1.144	0.183	0.665	0.488	0.533	0.279
9	8047.3	134993.8	30061.4	156626.3	76756.8	97990.4	27604.4	15426.7	2886	4899.9	8169.4
10	82.600	85.684	93.467	94.932	71.706	92.660	97.225	58.945	53.071	87.461	65.915
11	52.846	39.499	51.016	38.903	51.977	73.146	31.085	77.149	8.029	29.425	8.273
12	98.217	94.540	96.516	97.871	98.582	98.175	96.432	97.383	96.263	98.003	95.278
13	55	82.3	88.4	80.6	76.8	80	68.5	32.3	75.2	56.5	52
14	0.282	0.209	0.191	0.155	0.306	0.180	0.156	0.373	0.116	0.825	0.211
15	20.850	30.179	20.066	19.055	24.895	12.269	14.034	16.632	13.789	52.324	40.520
16	17.7	41.41	22.25	30.27	23.83	40.77	32.55	6.66	4.4	6.08	2.94
17	32214	14966	18025	15378	8824	12587	18246	12110	17389	17892	19893
18	4656.18	3690.34	4126.21	4121.21	2796.93	3102.6	3136.46	2723.79	3061.24	3681.42	3502.9
19	14432.55	14146.04	14367.55	12633.38	11758.76	13250.22	12857.89	10969.41	11640.43	12931.53	11432.1
20	33.3	37.4	41	34.8	41.3	39.1	32.9	39.1	34	36.2	33.9
21	2.419	3.382	5.550	11.230	6.588	2.176	9.487	1.876	1.543	2.265	0.466

Note: The date of pesticides consumption and the total marsh gas production come from the China rural statistical yearbook of 2009[7], the date of high-tech industrial output comes from the China's statistics yearbook on high technology industry of 2009[8].

(1)Standardize the original data and select the covariance matrix of standardized sample data as the sample data's correlation coefficient matrix R.

(2)The principal factors analysis was conducted. The eigenvalues of the main factors which were selected must be greater than 1 and the cumulative contribution rate of the main factors' explanation to the variances should be more than 85%. Based on the results of the principal component analysis, the number of common factors was determined. The result of the principal component analysis about the initial factors is shown in table3.

Table3 Coefficient matrix R's eigenvalues and the contribution rate

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.609	31.469	31.469	6.609	31.469	31.469
2	4.158	19.799	51.268	4.158	19.799	51.268
3	3.040	14.476	65.744	3.040	14.476	65.744
4	1.933	9.204	74.947	1.933	9.204	74.947
5	1.726	8.221	83.169	1.726	8.221	83.169
6	1.458	6.945	90.113	1.458	6.945	90.113
7	0.841	4.003	94.116			
8	0.624	2.972	97.088			
9	0.321	1.530	98.618			
10	0.290	1.382	100.000			
11	5.376E-16	2.560E-15	100.000			
12	3.299E-16	1.571E-15	100.000			
13	2.531E-16	1.205E-15	100.000			
14	1.319E-16	6.281E-16	100.000			
15	7.901E-17	3.762E-16	100.000			
16	-1.202E-17	-5.724E-17	100.000			
17	-1.162E-16	-5.535E-16	100.000			
18	-1.663E-16	-7.917E-16	100.000			
19	-2.816E-16	-1.341E-15	100.000			
20	-3.385E-16	-1.612E-15	100.000			
21	-7.832E-16	-3.730E-15	100.000			

(3)Calculating the initial factor loading matrix of the six main factors and the index variables, make an orthogonal rotation of the factors with the method of "maximum variance", then get the maximum variance factor loading matrix which is show in table 4.

Table 4 Component matrix of the initial factors and rotated component matrix

	Component Matrix						Rotated Component Matrix					
	1	2	3	4	5	6	1	2	3	4	5	6
1	-0.891	0.138	0.280	-0.080	0.280	-0.012	0.806	-0.354	-0.134	0.100	-0.265	0.316
2	-0.799	0.045	0.569	0.008	-0.039	0.112	0.951	-0.167	0.017	-0.079	0.068	0.222
3	-0.823	0.156	0.279	0.036	0.206	0.018	0.802	-0.283	-0.166	0.046	-0.200	0.164
4	0.275	0.595	0.124	0.114	0.542	-0.423	-0.118	-0.041	-0.114	0.975	0.086	0.017
5	0.462	-0.507	-0.016	0.482	-0.120	0.471	-0.126	0.599	0.027	-0.335	-0.068	-0.689
6	0.542	0.390	-0.085	0.489	-0.377	-0.139	-0.369	-0.019	-0.055	0.156	0.591	-0.468
7	0.457	-0.348	0.637	0.298	0.120	-0.215	0.106	0.493	0.581	0.294	0.120	-0.254
8	0.172	0.744	0.313	0.160	-0.272	-0.010	0.045	0.160	-0.333	0.240	0.496	0.135
9	0.739	0.255	0.179	0.038	0.156	0.237	-0.318	0.530	-0.088	0.243	0.123	0.015
10	0.643	-0.370	0.531	-0.165	-0.025	0.314	-0.086	0.926	0.292	-0.104	0.098	0.046
11	0.293	0.534	0.359	-0.250	-0.625	-0.039	-0.101	0.150	-0.037	0.046	0.926	0.308
12	-0.243	0.299	0.507	-0.733	-0.127	0.112	0.317	0.119	-0.027	-0.042	0.285	0.894
13	0.684	0.070	0.184	-0.061	0.601	-0.164	-0.359	0.579	0.101	0.615	-0.302	0.066
14	-0.630	-0.047	0.680	0.205	-0.092	0.244	0.970	0.048	0.026	-0.109	0.183	-0.017
15	-0.462	-0.345	0.450	0.568	0.173	0.175	0.776	0.025	0.149	-0.032	-0.213	-0.385
16	0.876	0.106	0.186	-0.094	-0.031	0.236	-0.446	0.780	-0.015	0.138	0.215	-0.019
17	-0.158	-0.820	0.003	-0.244	-0.263	-0.388	-0.008	-0.143	0.815	-0.429	-0.221	0.045
18	0.250	-0.723	0.385	-0.125	-0.057	-0.406	-0.018	0.193	0.946	-0.086	-0.095	0.030
19	0.547	-0.452	0.519	-0.037	-0.106	-0.325	-0.093	0.574	0.746	0.130	0.134	-0.098
20	0.218	0.744	0.421	0.170	0.012	-0.198	0.074	0.090	-0.227	0.692	0.618	0.059
21	0.544	-0.093	0.052	-0.464	0.386	0.420	-0.306	0.578	-0.103	0.083	-0.114	0.269

With calculation, the eigenvalues of the six main factors after orthogonal rotation was shown in Table 5.

Table 5 Rotation sums of squared loadings

Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	4.574	21.781	21.781
2	3.712	17.677	39.458
3	2.817	13.415	52.873
4	2.428	11.563	64.436
5	2.387	11.366	75.802
6	2.090	9.954	85.756

(4)The scores of factors，the total scores and order of the samples. According to the factor scores coefficient matrix, calculates the score of the each principal factor and sort them[9]. Take the variance contribution rate of the orthogonal rotated principal factors as the weight of the principal factors (They are 0.2540、0.2061、0.1564、0.1348、0.1326、0.1161), then calculate and evaluate the circular economy development scores of provinces in west China. The result is shown in table 6.

Table 6 Evaluation values and rank of the circular economy development in west China

Western Region	evaluation values													
	F_1	rank	F_2	rank	F_3	rank	F_4	rank	F_5	rank	F_6	rank	score	rank
Neimenggu	-0.028	4	-0.543	8	2.223	1	-0.859	10	0.300	5	1.006	2	0.269	4
Guangxi	-0.214	5	0.645	5	0.394	3	0.752	3	0.323	4	-2.147	11	0.035	6
Chongqing	-0.620	9	0.329	6	1.140	2	1.526	2	0.550	3	-0.327	8	0.329	2
Sichuan	-0.633	10	0.653	3	0.229	4	-0.306	5	-0.449	8	0.968	3	0.021	7
Guizhou	0.454	2	-0.020	7	-1.077	11	1.731	1	0.006	6	1.112	1	0.306	3
Yunnan	-0.590	8	1.041	2	-0.674	8	-0.387	7	0.776	2	0.857	4	0.109	5
Shaanxi	-0.751	11	1.291	1	-0.895	9	-1.224	11	-0.612	9	-0.333	9	-0.349	9
Gansu	0.104	3	-1.546	11	-0.974	10	-0.662	8	2.104	1	-0.256	7	-0.284	8
Qinghai	-0.289	7	-1.444	10	-0.381	7	0.617	4	-1.637	11	0.300	5	-0.530	10
Ningxia	2.812	1	0.646	4	0.135	5	-0.360	6	-0.293	7	-0.142	6	0.765	1
Xinjiang	-0.244	6	-1.053	9	-0.121	6	-0.828	9	-1.068	10	-1.038	10	-0.672	11

The figure of comprehensive evaluation score as follow:

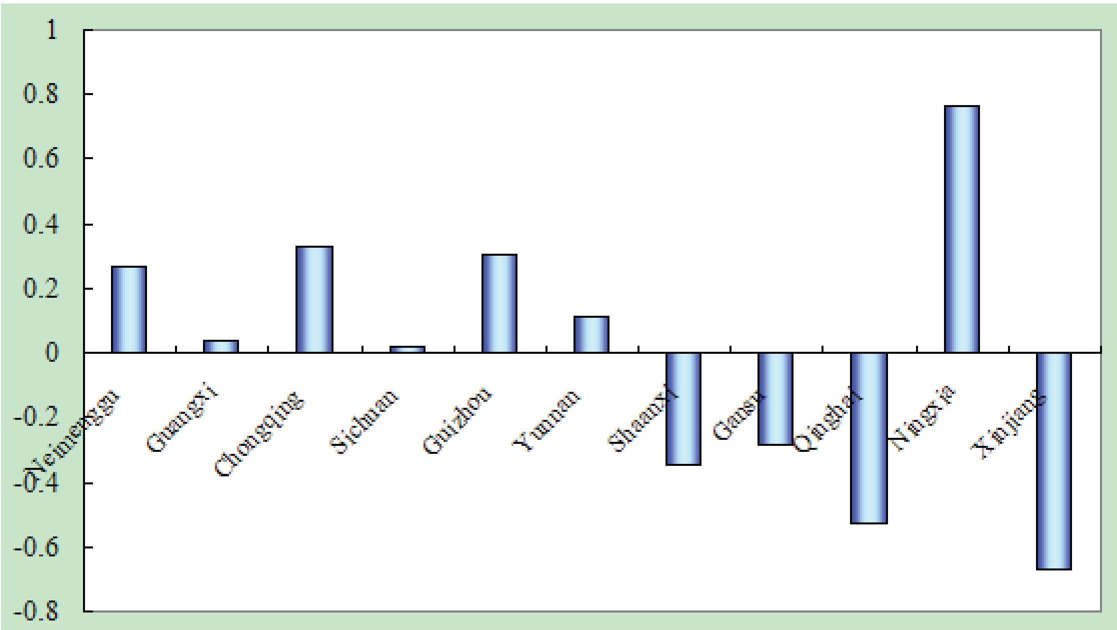

Figure 1 Evaluation histogram

5. Conclusions and policy suggestions

According to the evaluation score of each western province and municipality, it can be seen that the development of circular economy is uneven. The situation of Ningxia, Chongqing, Guizhou is the best in west China. The impacts on resource and environment of these three provinces are relatively small. The situation of Shaanxi, Gansu, Qinghai is relatively bad, it indicates that they take an extensive development path and have paid great resources and environmental cost. The circular economy situation of Xinjiang is the worst. The development foundation of Xinjiang is relatively weak and need to strengthen the construction of circular economy system, accelerate economic development model transformation. The suggestions are as follows:

Firstly, set up the regulation system to promote circular economy, promote environmental protection, waste recovery and comprehensive utilization through legislating.

Secondly, guide the development of circular economy through the fiscal and tax policies, change the simply pursuit of GDP growth thoroughly. Set up a new industrial and economic structure which accords with the demand for circular economy development.

Thirdly, depend on science and technology, set up the green technology design—develop— apply systemand form the overall strategy implementation systemof sustainable development.

Finally, develop ecological agriculture, set up industrial park of circular economy and ecological city.

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